LASER DOPPLER MEASUREMENT OF ATMOSPHERIC WIND VELOCITY

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ABSTRACT

Our presentation consists of two parts: (1) a summary review of laser Doppler principles and applications, and (2) operational design and preliminary laboratory tests of a CO_2 laser system for NOAA applications.

Laser Doppler velocimeters for short range applications to water tunnels and seeded-flow wind tunnels are widely used and reviewed[1]. The non-relativistic expression for the Doppler shift,

$$\nabla\nu_D = (n/2\pi)\, \vec{v} \cdot (\vec{k}_s - \vec{k}_o) ,$$

where n is the refractive index of the medium, $\vec{v}$ the scatterer velocity and $\vec{k}_s$ and $\vec{k}_o$ the scattered and incident wave vectors $(2\pi/\lambda)$, applies to both local measurement and remote measurement of flows. Remote velocity measurements with a single-ended system at ranges of tens of meters or more severely restrict the usable experimental configurations, however. We will critically review the atmospheric results of infrared heterodyne[2,3], two-beam visible differential[4], and visible incoherent[5] detection systems, as well as some signal to noise calculations[6].

For the measurement of wind in severe storm and boundary layer meteorology applications, considerations of background interference, atmospheric refractive index fluctuations, eye safety, laser stability and efficiency, and other practical concerns are properly discussed. Although a heterodyne, CO_2 laser system is attractive for these wind measurement purposes, an analysis of expected return based on the atmospheric aerosol model of McClatchey, et al.[7], is required to substantiate the adequacy of the technique.

We will present an outline of the NOAA Doppler lidar equipment and exhibit velocity data from a diffuse scattering source at 12 meters. Conference

participants are invited to an interactive discussion of the application of this type of laser radar to problems such as waterspouts, thunderstorms, and helical rolls.

References

[1] M. J. Rudd, Optics and Laser Tech., p. 200 (Nov. 1971).

[2] R. M. Huffaker, A. V. Jelalian, and J. A. L. Thomson, Proc. IEEE 58, p. 322 (1970).

[3] T. R. Lawrence, D. J. Wilson, C. E. Craven, I. P. Jones, R. M. Huffaker, and J. A. L. Thomson, Rev. Sci. Inst., 43, p. 512 (1972).

[4] W. M. Farmer and D. B. Brayton, Appl. Opt., 10, p. 3219 (1971).

[5] G. Benedetti-Michelangeli, F. Congeduti, and G. Fiocco, J. Atmos. Sci., 29, p. 906 (1972).

[6] C. M. Sonnenschein and F. A. Horrigan, Appl. Opt., 10, p. 1600 (1971).

[7] R. A. McClatchey, R. W. Fenn, J. E. A. Selby, F. E. Volz, and J. S. Garing, Air Force Cambridge Research Laboratories, Rept. AFCRL-71-0279 (1971).